DLR Knowledge for Tomorrow

Tracing Personal Data Using Comics

Andreas Schreiber
German Aerospace Center (DLR)

Regina Struminski
University of Applied Science Düsseldorf

Introduction

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

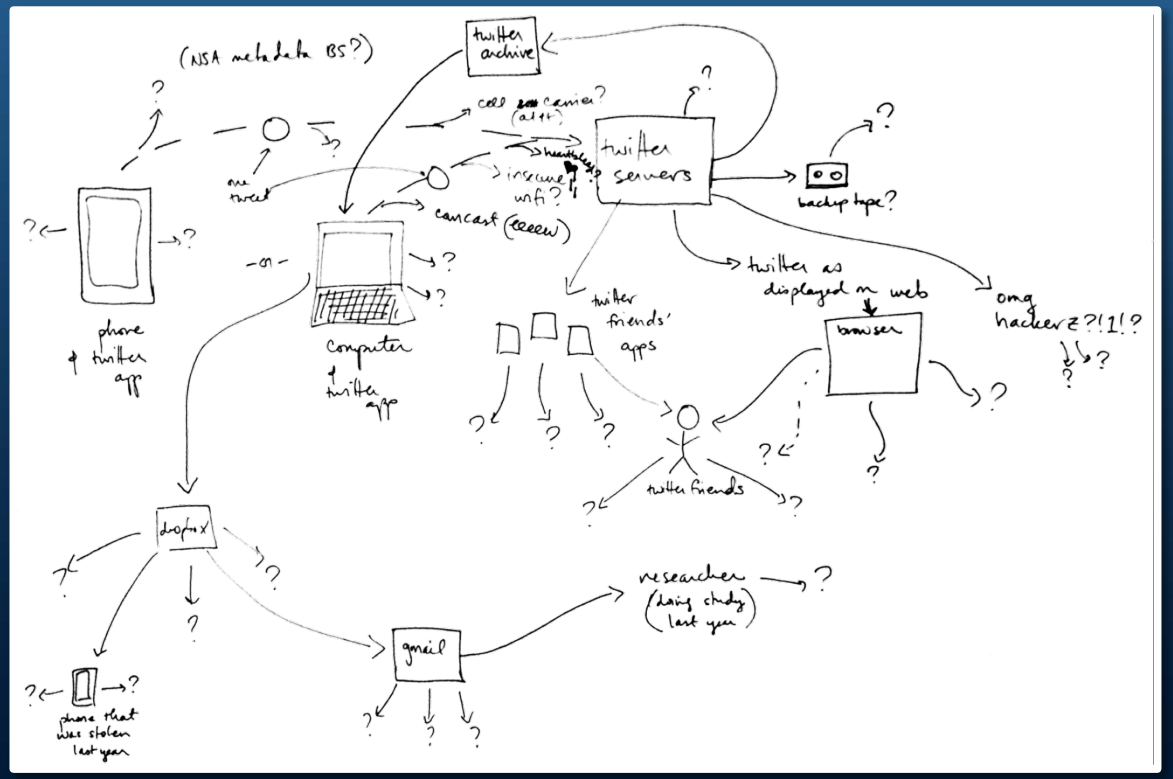
Simulation and Software Technology, Cologne/Berlin
Head of Intelligent and Distributed Systems department

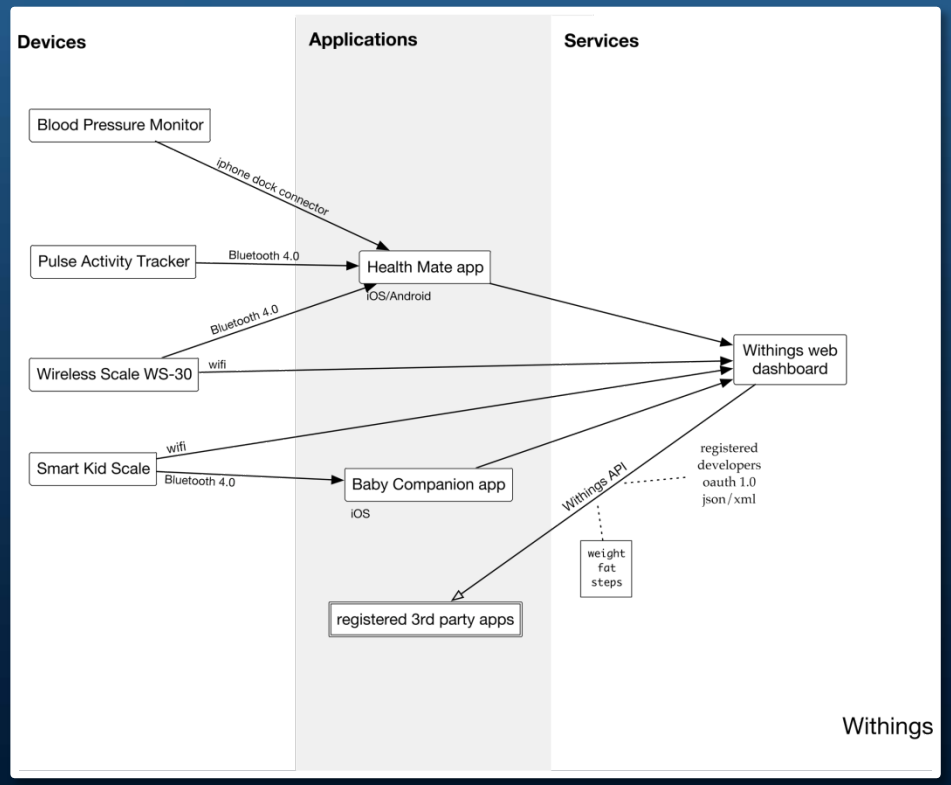
Institute of Data Science, Jena
Head of Secure Software Engineering group

Co-Founder
Data Scientist
Patient

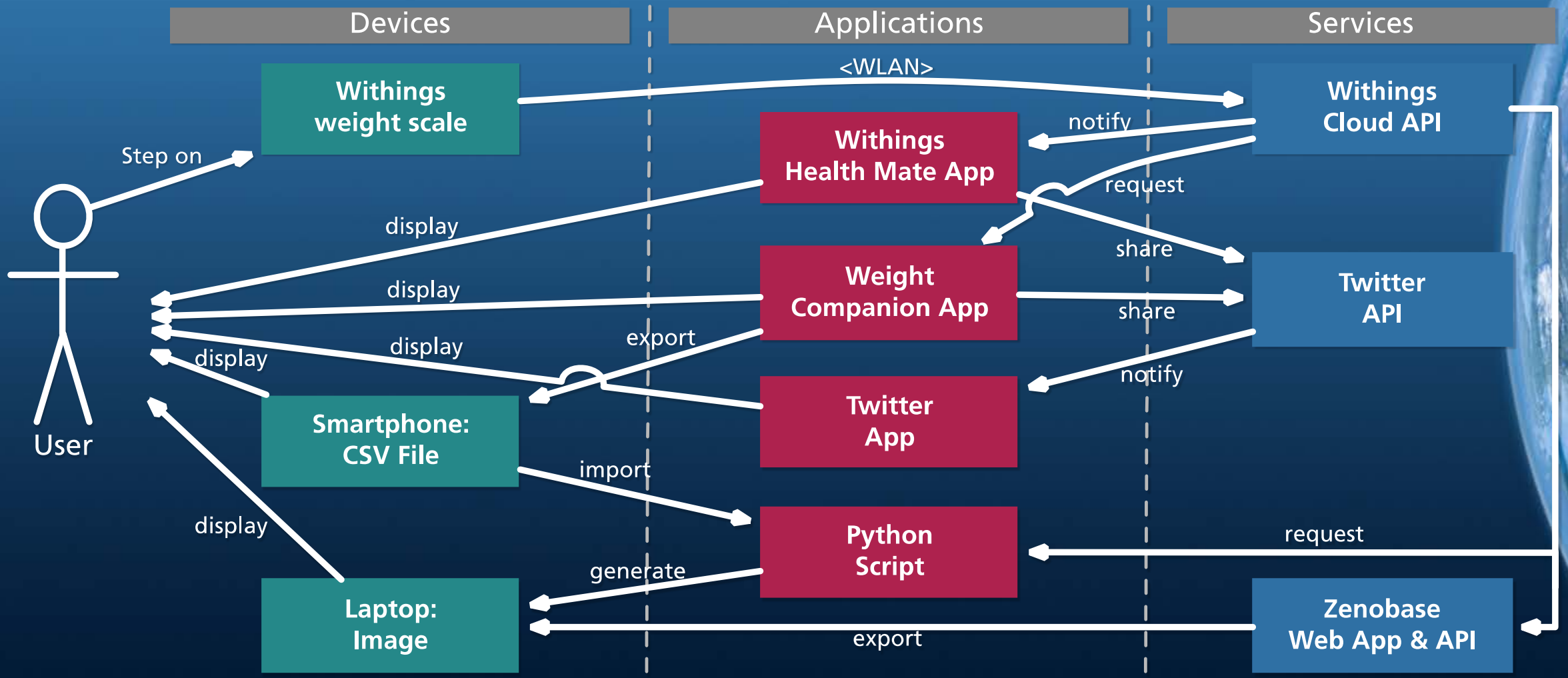
Understand, how Quantified Self data has been produced, processed, stored, accessed, …

Pictures from *Breakout Session on Mapping Data Access* (2014 QS Europe Conference, Amsterdam)
`https://forum.quantifiedself.com/t/breakout-mapping-data-access/995`





Example: Weight Tracking Workflow



Questions related to Quantified Self

Data

- What data about the user were created during the activity X?
- What data about the user were automatically generated?
- What data about the user were derived from manual input?

Apps and Services

- Which activities support visualization of the users data?
- In which activities can the user input data?
- What processes are communicating data?

Access and Privacy

- What parties were involved in generating data X?
- What parties got access on data X?
- Can other parties see user’s data X?

Provenance

Provenance is

information about entities, activities, and people

involved in

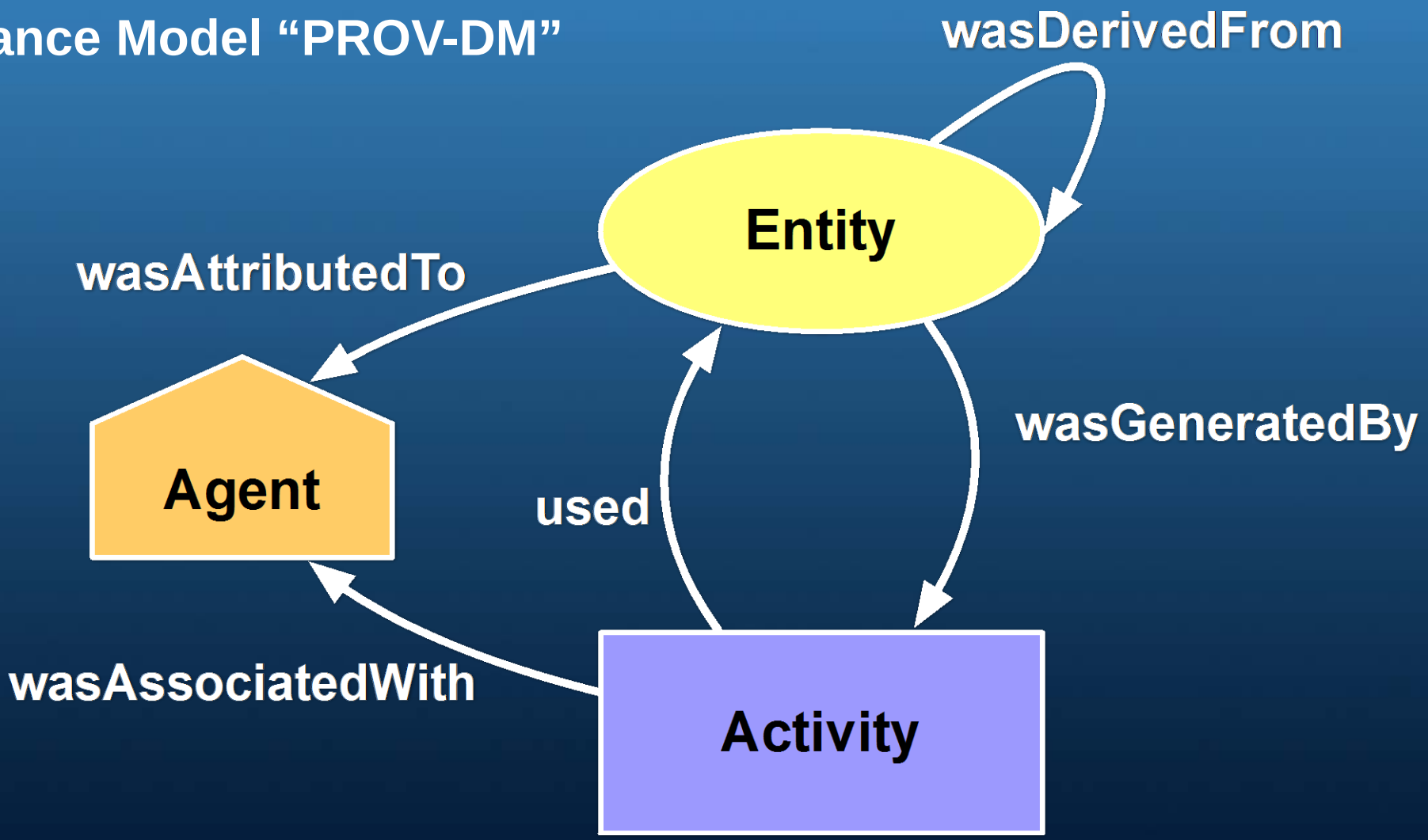
producing a piece of data or thing,

which can be used to form

assessments about its quality, reliability or trustworthiness.

PROV W3C Working Group
https://www.w3.org/TR/prov-overview

Provenance Model “PROV-DM”



Provenance Model for Quantified Self

Sub models for basic QS *Activities*

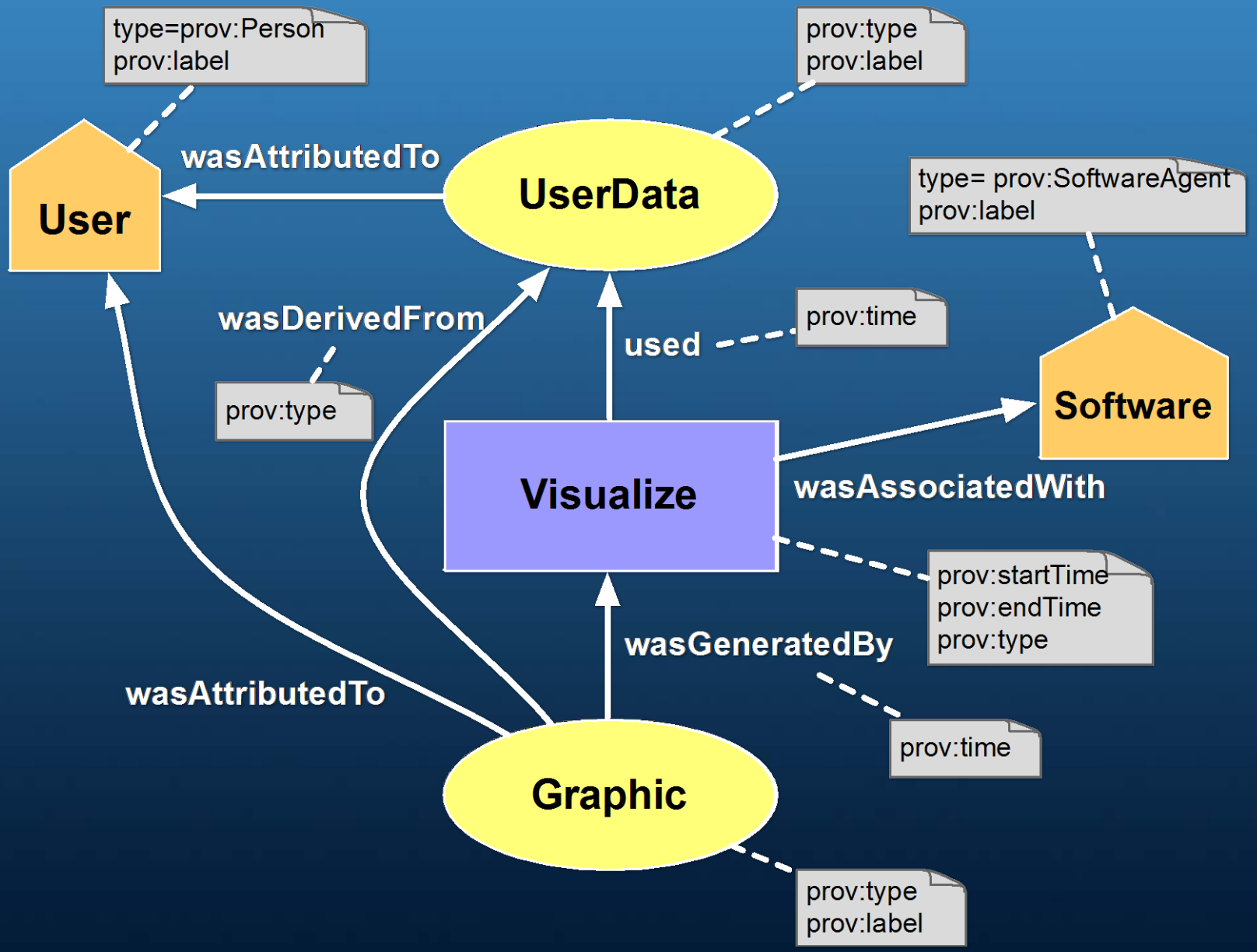
- Input
- Sensing
- Export
- Request
- Aggregate
- Visualize

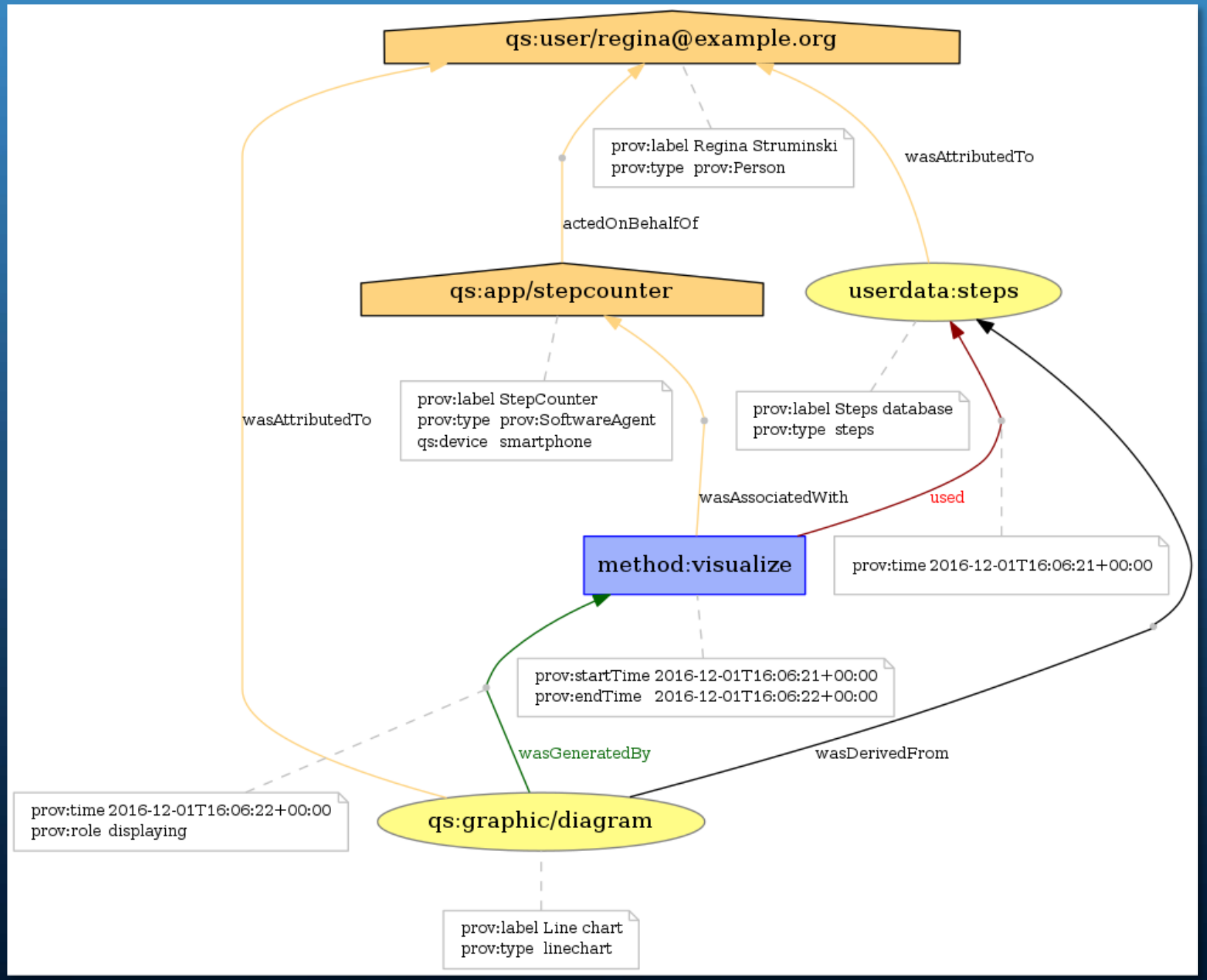
The activities generate or change data that is associated or attributed to *Agents*

- Users
- Software
- Organizations

References

- Schreiber, A. (2016) ***A Provenance Model for Quantified Self Data***. In: Universal Access in Human-Computer Interaction. Methods, Techniques, and Best Practices: 10th International Conference, UAHCI 2016, Held as Part of HCI International 2016, Toronto, ON, Canada, July 17-22, 2016, Proceedings, Part I, Springer, 382-393
- Schreiber A., Seider D. (2016) ***Towards Provenance Capturing of Quantified Self Data***. In: Provenance and Annotation of Data and Processes. IPAW 2016. Lecture Notes in Computer Science, vol 9672. Springer, Cham


type=prov:Person
prov:label
prov:type
prov:label
wasAttributedTo
User
UserData
type= prov:SoftwareAgent
prov:label
wasDerivedFrom
prov:type
used
prov:time
Software
Visualize
wasAssociatedWith
prov:startTime
prov:endTime
prov:type
wasGeneratedBy
wasAttributedTo
prov:time
Graphic
prov:type
prov:label


qs:user/regina@example.org
prov:label Regina Struminski
prov:type prov:Person
wasAttributedTo
actedOnBehalfOf
qs:app/stepcounter
userdata:steps
wasAttributedTo
prov:label StepCounter
prov:type prov:SoftwareAgent
qs:device smartphone
prov:label Steps database
prov:type steps
wasAssociatedWith
used
method:visualize
prov:time 2016-12-01T16:06:21+00:00
prov:startTime 2016-12-01T16:06:21+00:00
prov:endTime 2016-12-01T16:06:22+00:00
wasGeneratedBy
wasDerivedFrom
prov:time 2016-12-01T16:06:22+00:00
prov:role displaying
qs:graphic/diagram
prov:label Line chart
prov:type linechart

```
document
  prefix userdata <http://software.dlr.de/qs/userdata/>
  prefix qs <http://software.dlr.de/qs/>
  prefix graphic <http://software.dlr.de/qs/graphic/>
  prefix app <http://software.dlr.de/qs/app/>
  prefix user <http://software.dlr.de/qs/user/>
  prefix device <http://software.dlr.de/qs/device/>
  prefix method <http://www.java.com>

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  activity(method:visualize, 2016-12-01T16:06:21+00:00, 2016-12-01T16:06:22+00:00)
  entity(qs:graphic/diagram, [prov:type="linechart", prov:label="Line chart"])
  entity(userdata:steps, [prov:type="steps", prov:label="Steps database"])
  agent(qs:user/regina@example.org, [prov:type="prov:Person", prov:label="Regina Struminski"])
  agent(qs:app/stepcounter, [prov:type="prov:SoftwareAgent", qs:device="smartphone", prov:label="StepCounter"])
  wasAttributedTo(qs:graphic/diagram, qs:user/regina@example.org)
  wasAttributedTo(userdata:steps, qs:user/regina@example.org)
  actedOnBehalfOf(qs:app/stepcounter, qs:user/regina@example.org, -)
  used(method:visualize, userdata:steps, 2016-12-01T16:06:21+00:00)
  wasDerivedFrom(qs:graphic/diagram, userdata:steps, -, -, -)
  wasAssociatedWith(method:visualize, qs:app/stepcounter, -)
endDocument
```

Standard Graph Visualizations and Textual Representations of Provenance Data are not Easy to Understand by Non-experts

Idea: Provenance Visualization Using Comics

Provenance Comics

- Presenting the provenance of processes in visual representation that people can understand without prior instructions or training (“Provenance for people”)
- Assumption
  - People are familiar with comics from every day life
  - See *daily strips* in newspapers etc.

Provenance Comics

Design considerations

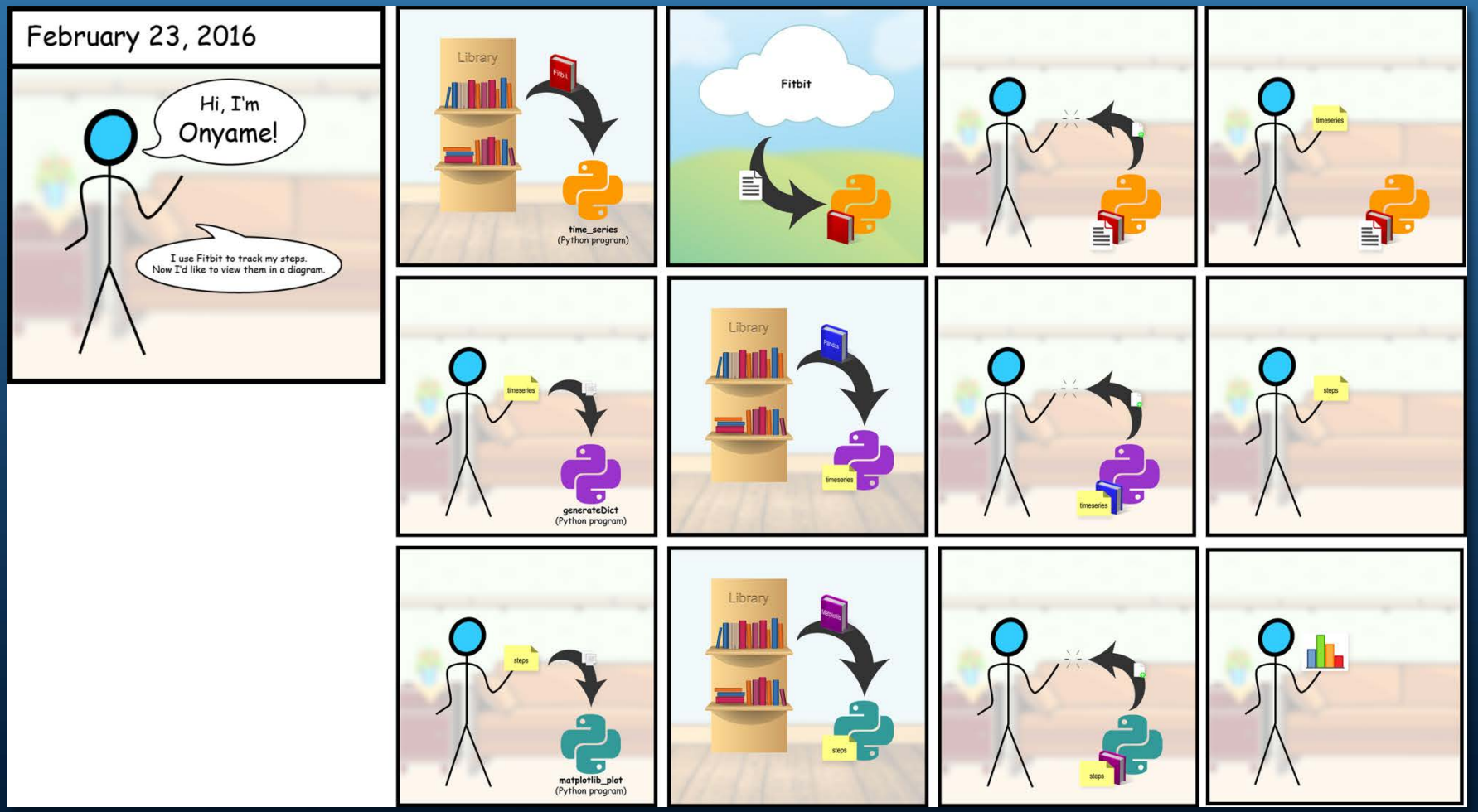
- Data provenance has a temporal aspect: origin, manipulation, transformation, and other activities happen sequentially over time
- The directed acyclic provenance graph guarantees that, while moving through its nodes, one always moves linearly forward in time
- It’s possible to derive a temporal sequence of happenings from the graph that can be narrated like a story

Provenance Comics

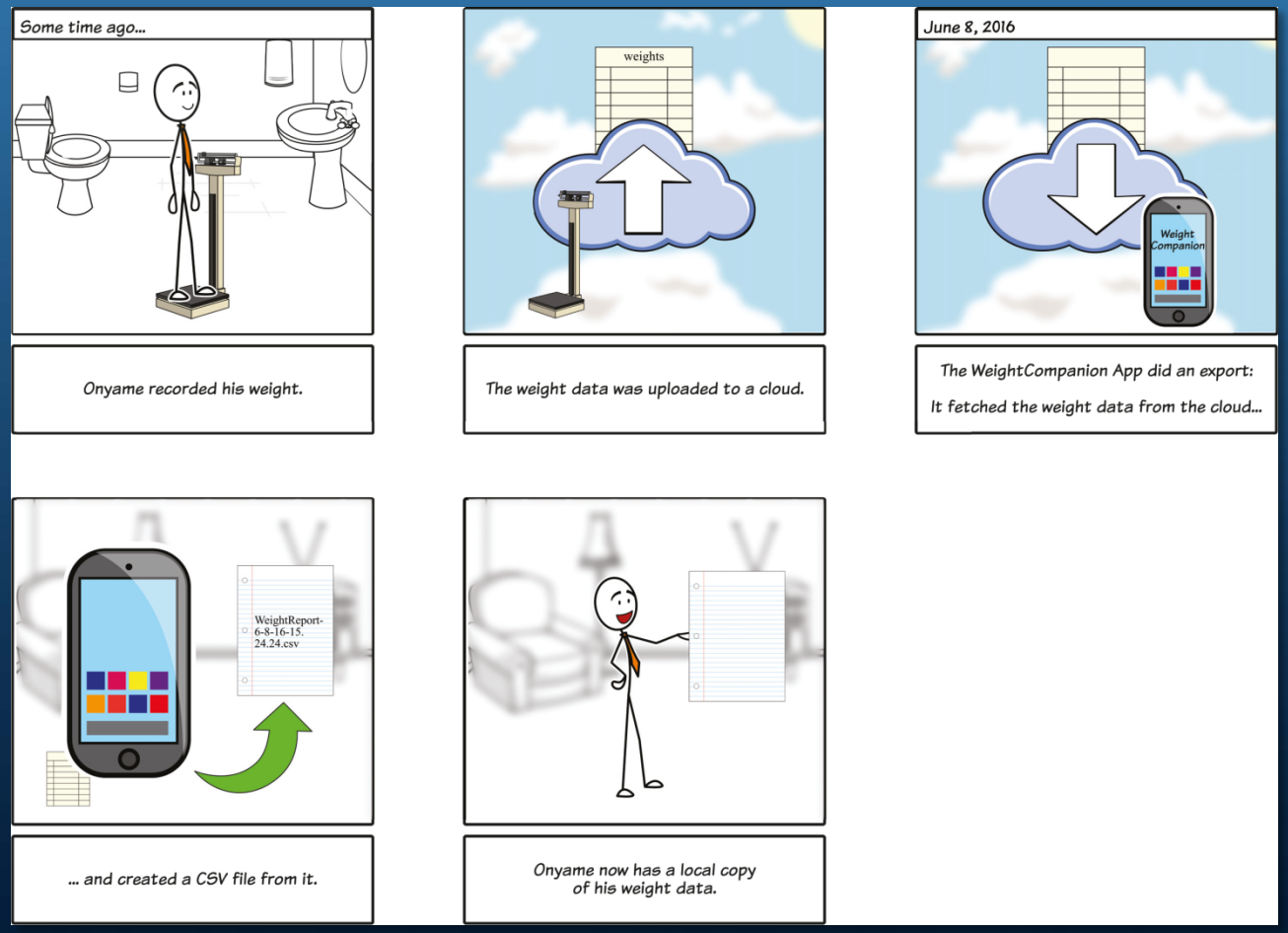
Mapping provenance graph to comics

- We generate a comic strip for each basic activity in the provenance graph
- Each strip consists of a varying number of panels, which are small drawings that provide further details about the activity
- The complete set of comic strips shows the “story” of the data

First Sketches



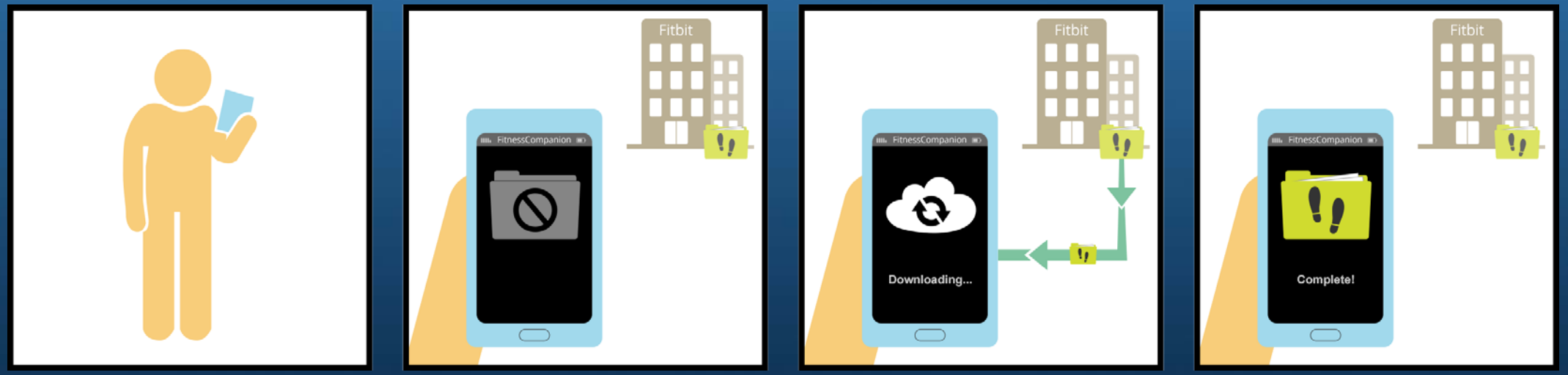
First Sketches



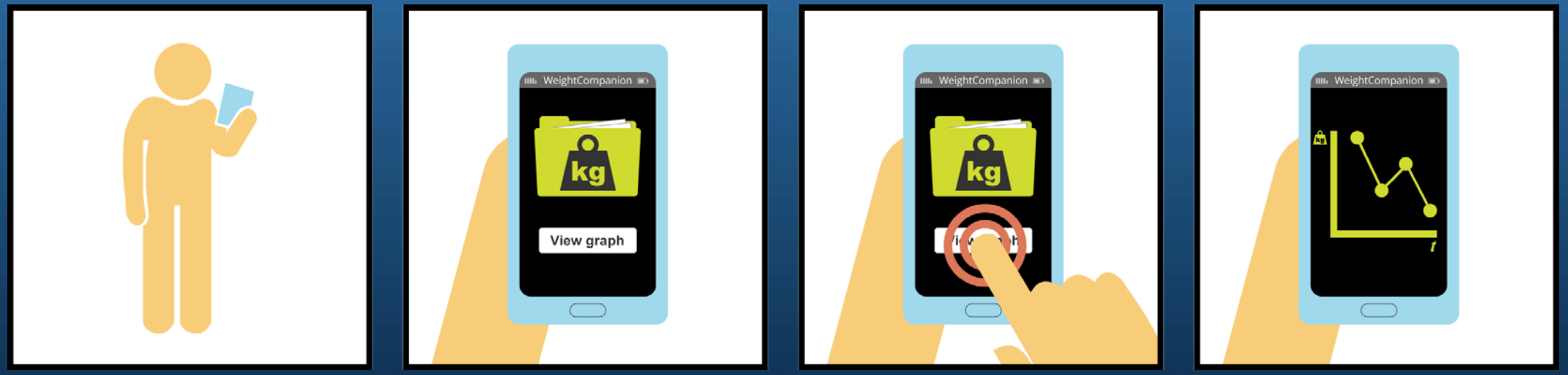
Current Graphical Style

Single Comic Strip Shows a Single Data-related Action

Communicate to People Where Data is Stored

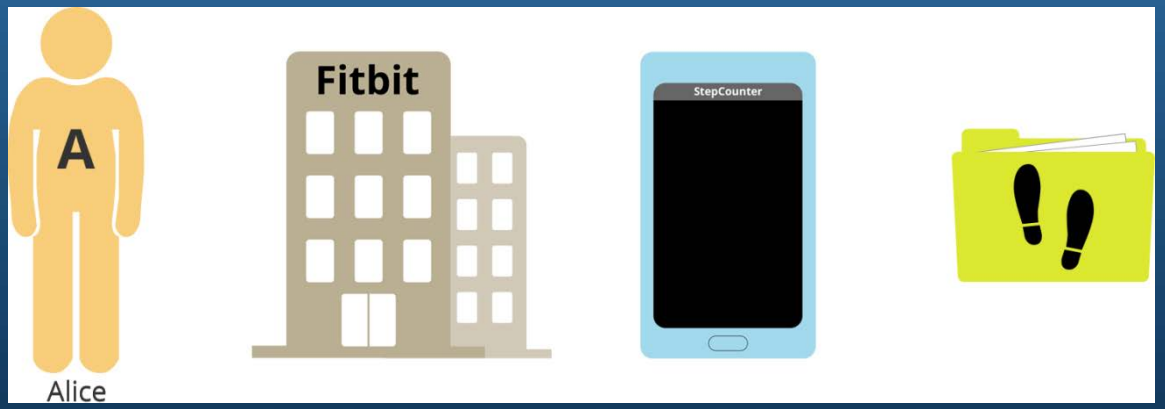


Understand How Data is Analyzed



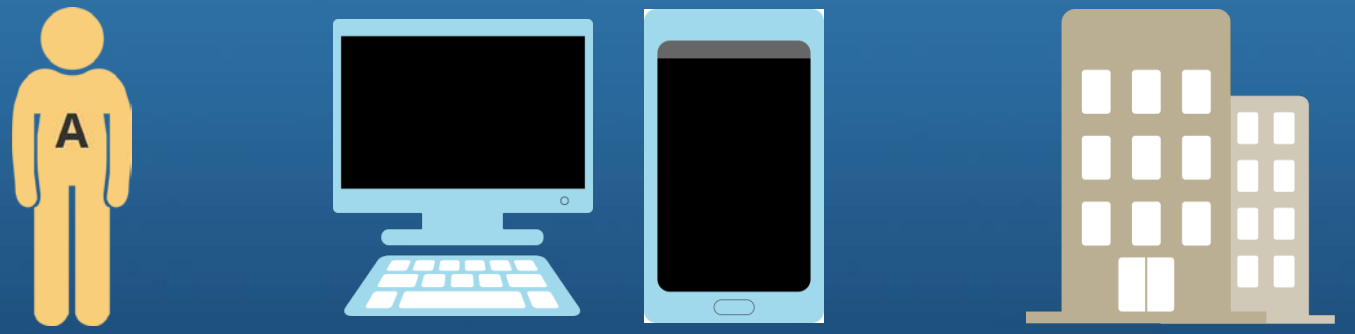
Distinctive Features

- Shapes
- Colors
- Icons
- Letters
- Labels

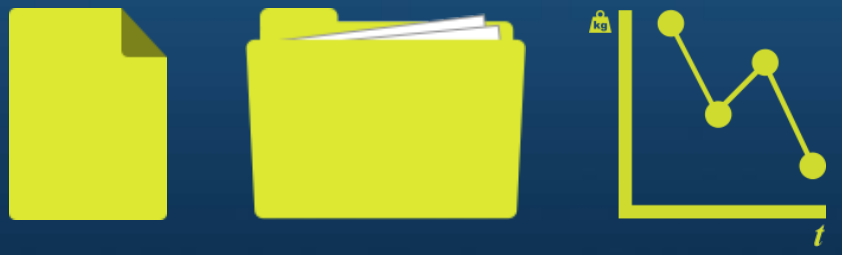


Representation of PROV Elements

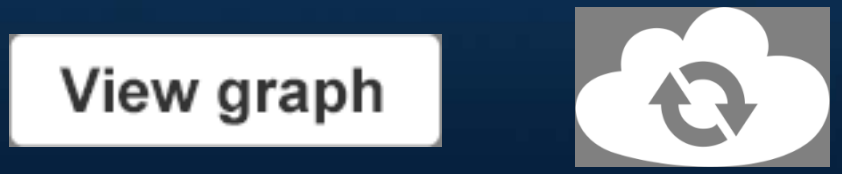
Agents



Entities



Activity-related



Qualitative User Study

Research questions

1. Are the selected graphics and the visual language they form understandable?
2. Do users understand the history of their own data (i.e., when and how their data originated, what conversions and transformations it underwent, and who had access to or control over it in the course of time)?

Study design

- Ten test subjects were shown a number of test comics and asked to re-narrate the story as they understood it
- Test subjects had no previous knowledge about data provenance and no special expertise in the Quantified Self domain
- Five different scenarios as test comics with two to five activities

User Study – Test Sheet

Sheet 1

Please imagine the following scenario:

You wear a **fitness bracelet** every day,
counting the steps you take.

On your smartphone, there is an app called **„StepsCompanion“**,
which automatically syncs with your bracelet.

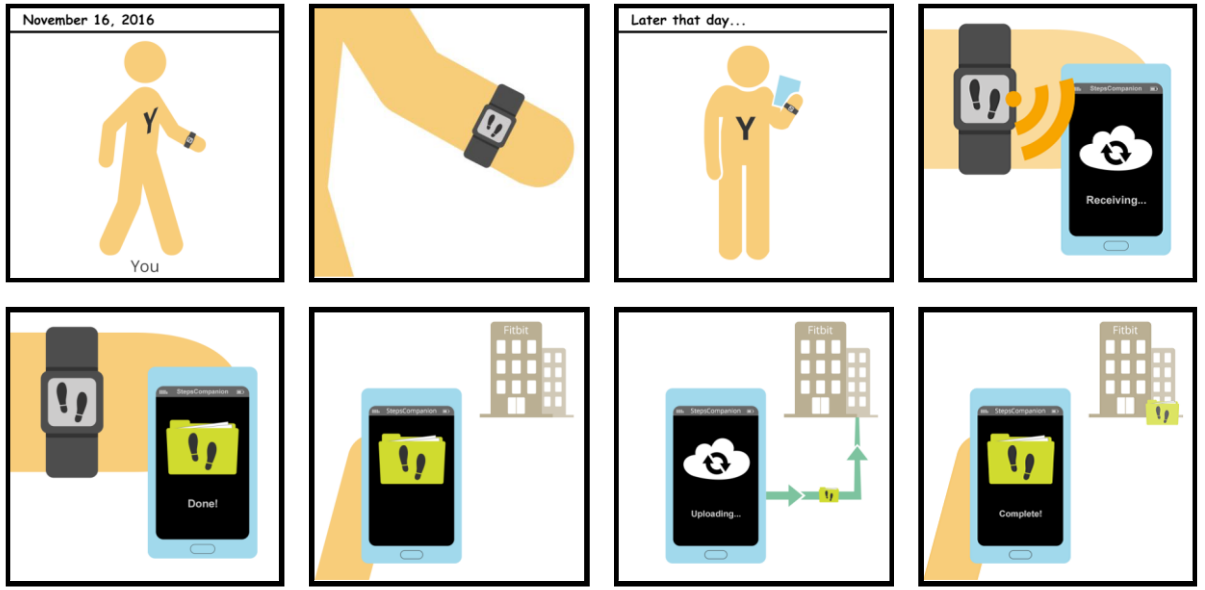
This way you can always view on your phone
how much you have already walked during the day.

You are now viewing your steps from November 16, 2016 in the app:

The button *"Origin of this data"* makes you curious.

So you tap it and get to see the following:

Test subject _____ Page 1/2



Please take your time to inspect and interpret these pictures.

When you are ready, please tell the examiner what the pictures convey in your understanding.

Feel free to elaborate in great detail – mention anything that occurs to you or catches your attention.

Test subject _____ Page 2/2

User Study – Results

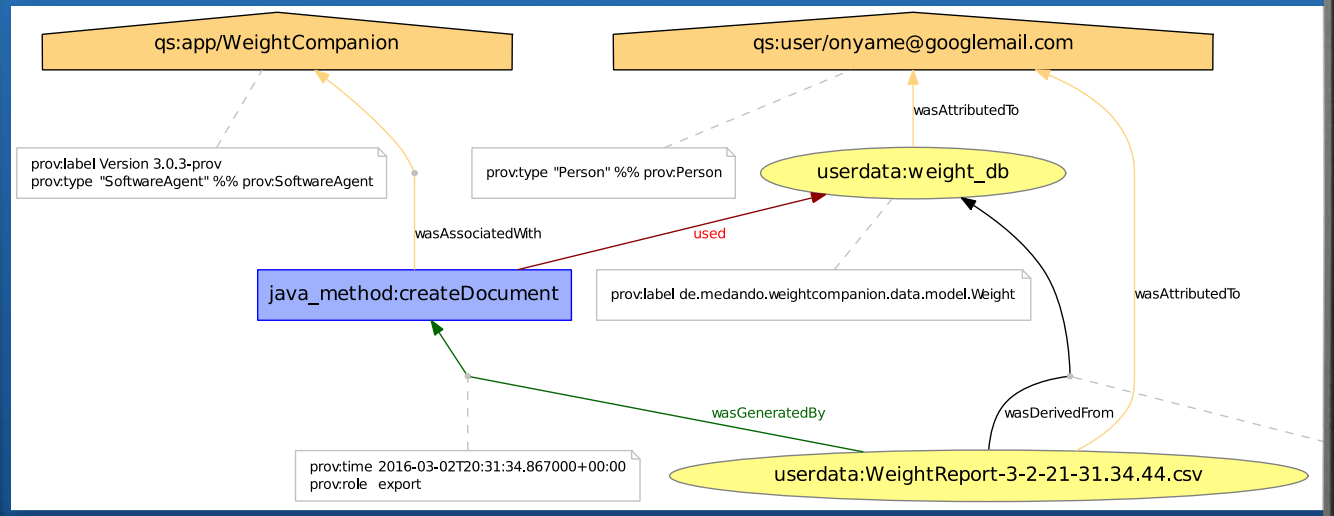
- Average percentage of findings that participants verbalized over all five comics was 77%
- The value was remarkably high for some particular comics, the highest one being 87%
- Women showed a better overall performance than men (84% for women vs. 73% for men)
- There were certain difficult parts in some of the comics, which mostly stemmed from a lack of experience with Quantified Self applications or web services. However, even in these cases, the general essence of the story was largely interpreted correctly
- Participants had no difficulties recognizing and interpreting the different icons for concrete elements, like persons, smartphones, computers, and bracelets or smartwatches
- Even more abstract notions (e.g., “transmitting data from one device to another,” “synchronizing data with a cloud”) were well-understood
- In summary, all users were able to explain correctly the scenarios depicted in the comic strips

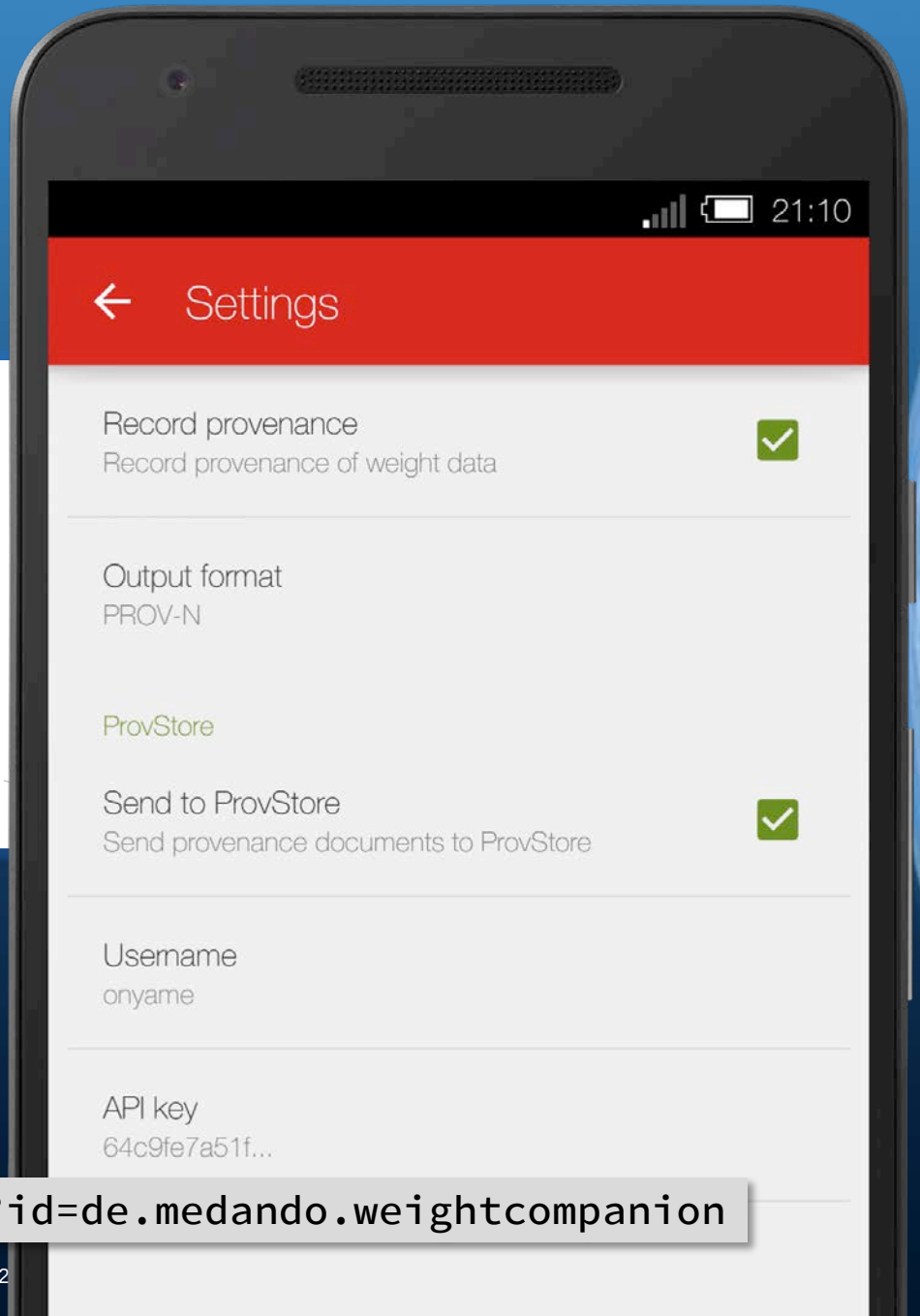
User Study – Some special findings

Some users suggested minor changes and improvements to the visual representation

- **“Origin of this data” button**: All participants where asked what they think the purpose of the comics might be. Eight out of ten thought that the comics were meant to be instruction manuals, providing hints on how to use the smartphone or computer app in combination with wearables or other measuring devices
- **Weight icon**: One reader explicitly said that weight data was apparently recorded in kilograms. Since this does not always have to be the case, the “kg” label on the weight icon should be reconsidered
- **Tracking device**: In one situation, a reader did not recognize that the icon on a tracking bracelet had changed and heart rate was now being tracked instead of steps
- **The term “export”**: Only one reader had some minor difficulties with the term “export”
- **“Missing data” icon**: One user suggested that the grayed-out folder icon should be modified to indicate whether data is just outdated or missing completely

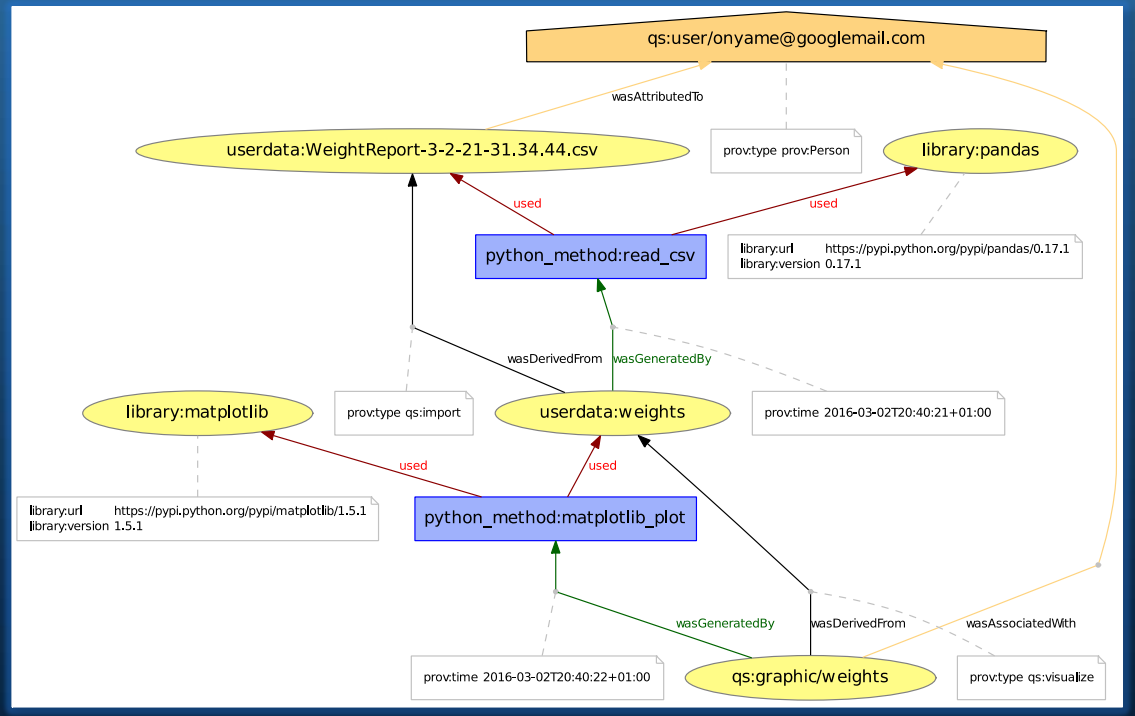
Collecting QS Provenance
Weight Tracking App



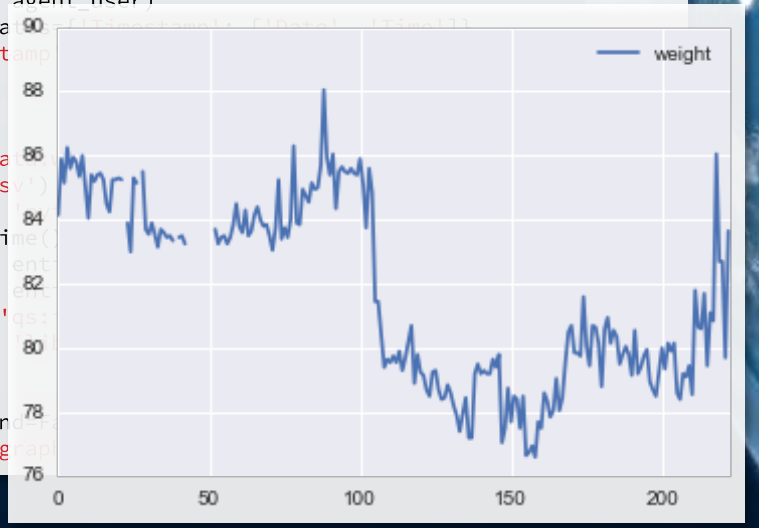


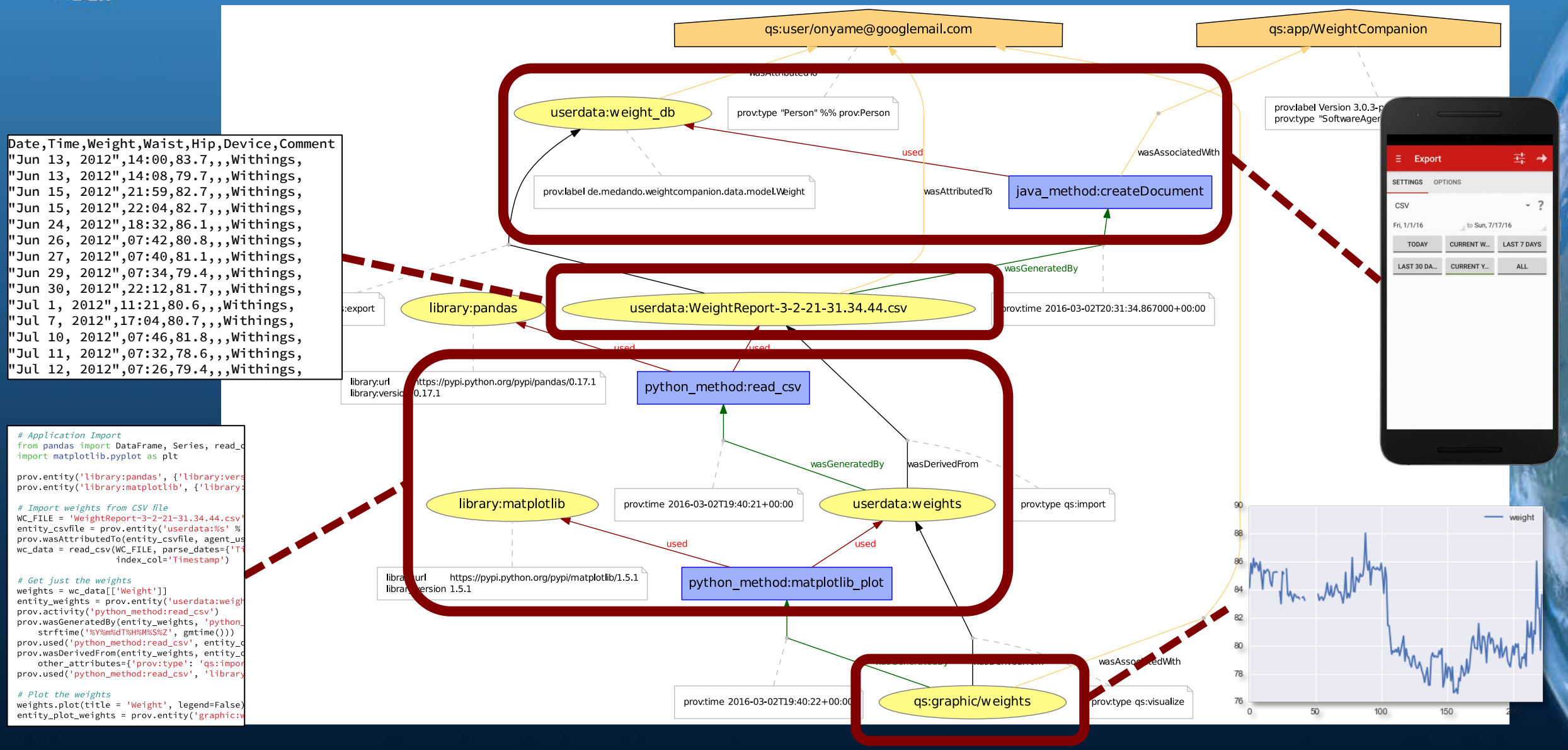
https://play.google.com/store/apps/details?id=de.medando.weightcompanion

Collecting QS Provenance
Visualization with Python Script




```
# Provenance-related Imports
from prov.model import ProvDocument, PROV
from provstore.api import Api
from time import gmtime, strftime

# Create a new provenance document
prov = ProvDocument()

# Add namespaces
prov.add_namespace('qs', 'http://software.dlr.de/qs/')
prov.add_namespace('userdata', 'http://software.dlr.de/qs/userdata/')
prov.add_namespace('user', 'http://software.dlr.de/qs/user/')
prov.add_namespace('graphic', 'http://software.dlr.de/qs/graphic/')
prov.add_namespace('library', 'https://pypi.python.org/pypi/')
prov.add_namespace('python_method', 'http://www.python.org')

# The user
agent_user = prov.agent('user:onyame@googlemail.com', {'prov:type': PROV['Person']})

# Application Import
from pandas import DataFrame, Series, read_csv
import matplotlib.pyplot as plt

prov.entity('library:pandas', {'library:version': pd.__version__})
prov.entity('library:matplotlib', {'library:version': matplotlib.__version__})

# Import weights from CSV file
WC_FILE = 'WeightReport-3-2-21-31.34.44.csv'
entity_csvfile = prov.entity('userdata:%s' % WC_FILE)
prov.wasAttributedTo(entity_csvfile, agent_user)
wc_data = read_csv(WC_FILE, parse_da
                   index_col='Timest

# Get just the weights
weights = wc_data[['Weight']]
entity_weights = prov.entity('userda
prov.activity('python_method:read_cs
prov.wasGeneratedBy(entity_weights,
    strftime('%Y%m%dT%H%M%S%Z', gmti
prov.used('python_method:read_csv',
prov.wasDerivedFrom(entity_weights,
    other_attributes={'prov:type': '
prov.used('python_method:read_csv',

# Plot the weights
weights.plot(title = 'Weight', legen
entity_plot_weights = prov.entity('g
```




Date,Time,Weight,Waist,Hip,Device,Comment
"Jun 13, 2012",14:00,83.7,,,Withings,
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"Jun 15, 2012",21:59,82.7,,,Withings,
"Jun 15, 2012",22:04,82.7,,,Withings,
"Jun 24, 2012",18:32,86.1,,,Withings,
"Jun 26, 2012",07:42,80.8,,,Withings,
"Jun 27, 2012",07:40,81.1,,,Withings,
"Jun 29, 2012",07:34,79.4,,,Withings,
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"Jul 11, 2012",07:32,78.6,,,Withings,
"Jul 12, 2012",07:26,79.4,,,Withings,
# Application Import
from pandas import DataFrame, Series, read_c
import matplotlib.pyplot as plt
prov.entity('library:pandas', {'library:vers
prov.entity('library:matplotlib', {'library:
# Import weights from CSV file
WC_FILE = 'WeightReport-3-2-21-31.34.44.csv'
entity_csvfile = prov.entity('userdata:%s' %
prov.wasAttributedTo(entity_csvfile, agent_us
wc_data = read_csv(WC_FILE, parse_dates={'Ti
index_col='Timestamp')
# Get just the weights
weights = wc_data[['Weight']]
entity_weights = prov.entity('userdata:weigh
prov.activity('python_method:read_csv')
prov.wasGeneratedBy(entity_weights, 'python_
strftime('%Y%m%dT%H%M%S%Z', gmtime()))
prov.used('python_method:read_csv', entity_c
prov.wasDerivedFrom(entity_weights, entity_c
other_attributes={'prov:type': 'qs:impor
prov.used('python_method:read_csv', 'library
# Plot the weights
weights.plot(title = 'Weight', legend=False)
entity_plot_weights = prov.entity('graphic:w
qs:user/onyame@googlemail.com
qs:app/WeightCompanion
userdata:weight_db
prov:type "Person" %% prov:Person
used
wasAssociatedWith
prov:label de.medando.weightcompanion.data.model.Weight
wasAttributedTo
java_method:createDocument
wasGeneratedBy
library:pandas
userdata:WeightReport-3-2-21-31.34.44.csv
prov:time 2016-03-02T20:31:34.867000+00:00
used
used
library:url https://pypi.python.org/pypi/pandas/0.17.1
python_method:read_csv
wasGeneratedBy
wasDerivedFrom
library:matplotlib
prov:time 2016-03-02T19:40:21+00:00
userdata:weights
prov:type qs:import
used
used
library:url https://pypi.python.org/pypi/matplotlib/1.5.1
python_method:matplotlib_plot
prov:time 2016-03-02T19:40:22+00:00
qs:graphic/weights
wasAssociatedWith
prov:type qs:visualize
Export
SETTINGS
OPTIONS
CSV
Fri, 1/1/16
to Sun, 7/17/16
TODAY
CURRENT W...
LAST 7 DAYS
LAST 30 DA...
CURRENT Y...
ALL
weight
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88
86
84
82
80
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76
0
50
100
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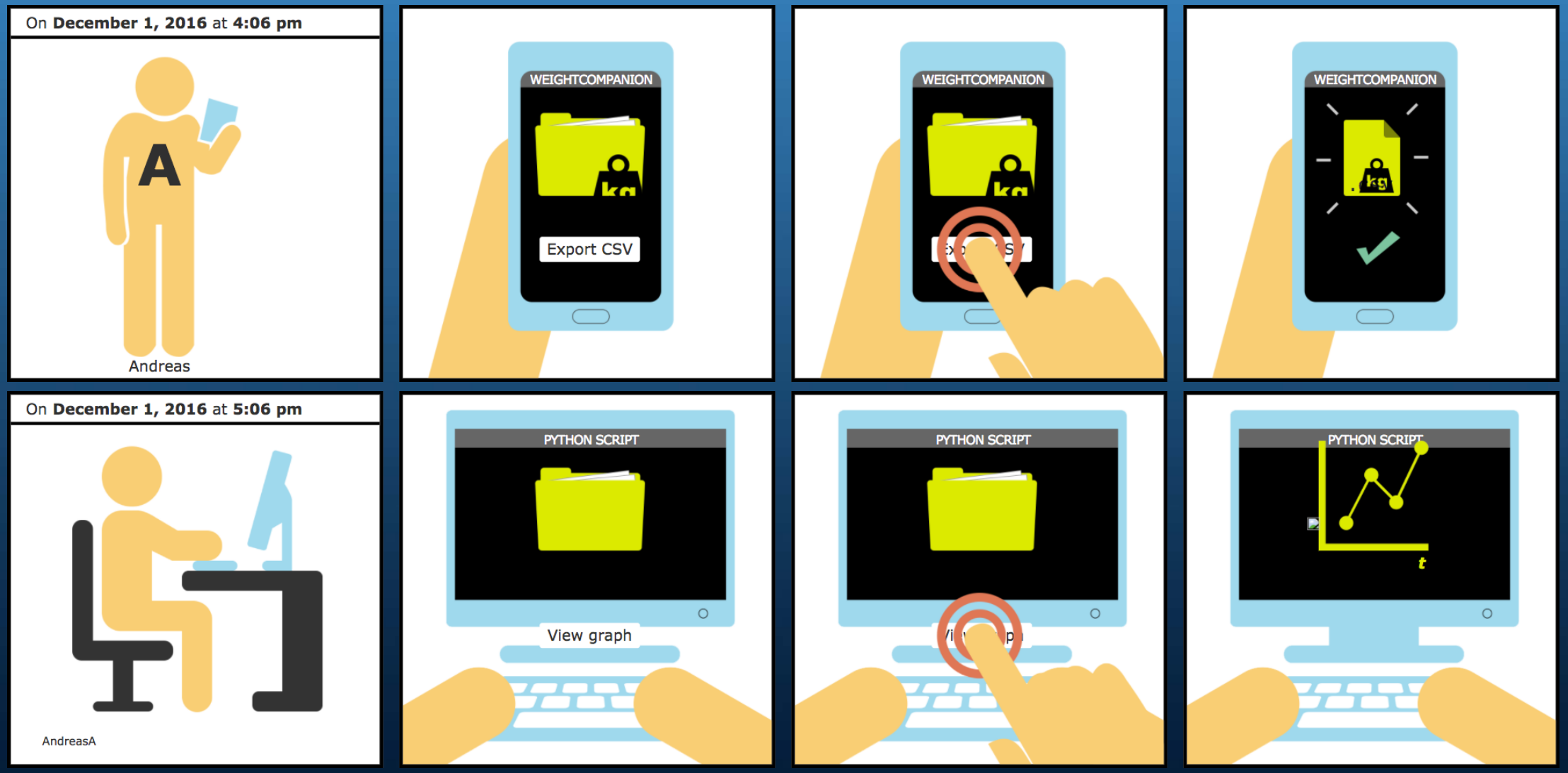
On December 1, 2016 at 4:06 pm
A
Andreas
WEIGHTCOMPANION
Export CSV
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WEIGHTCOMPANION
On December 1, 2016 at 5:06 pm
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PYTHON SCRIPT
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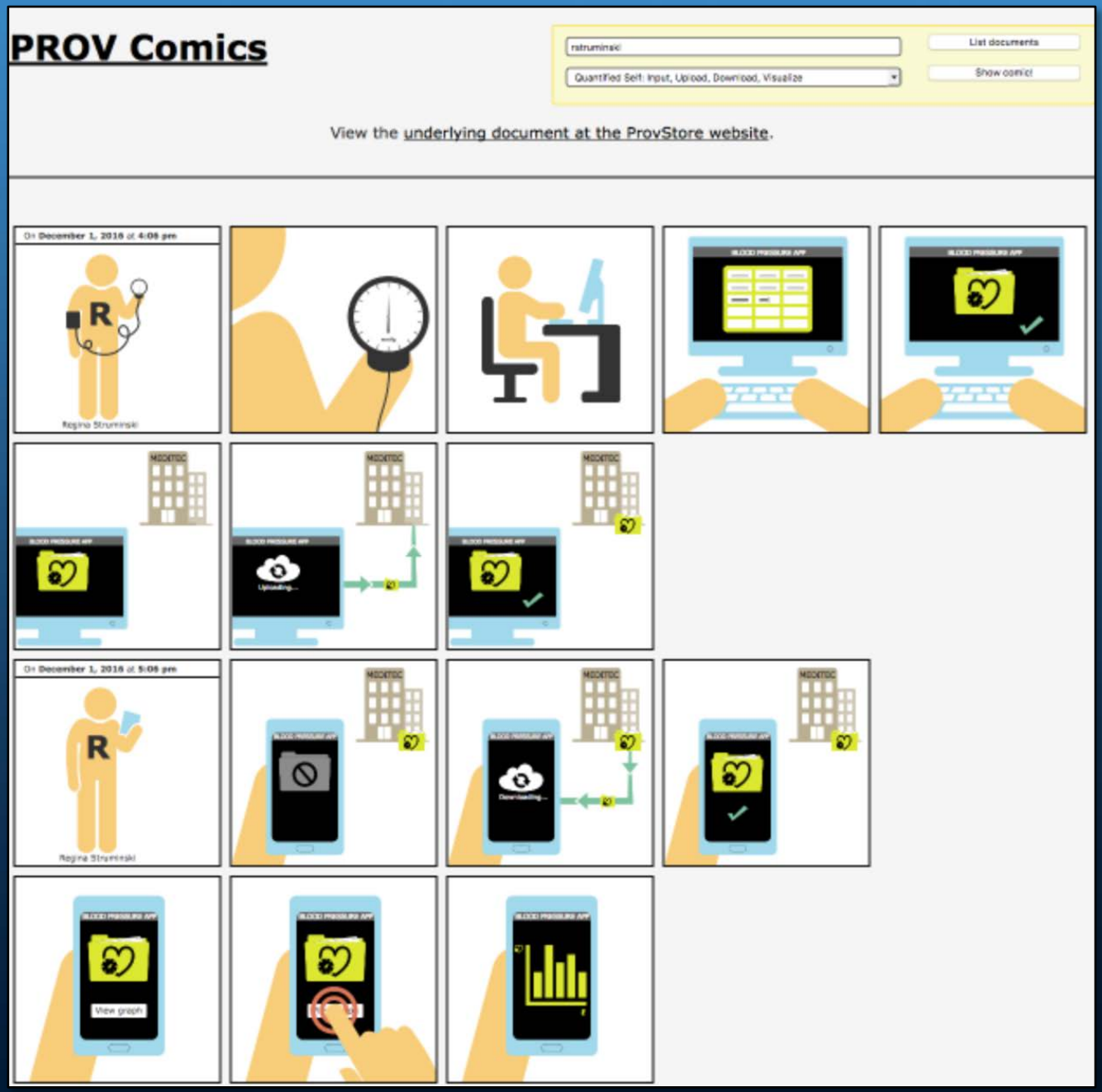
PYTHON SCRIPT
PYTHON SCRIPT
t

PROV Comics
Web Application

`http://provcomics.de`

- Implemented in JavaScript
- Single page website
- Reads provenance graph from ProvStore
- Uses ProvStore jQuery API
- Code: `http://github.com/DLR-SC/prov-comics`



Future Work and Use Cases

Future Work

- Different comic styles
  - Comparative user studies
- Quantitative comics
  - Geographical information
  - Glyph-based depiction
- Technical improvements
  - Large Provenance graphs
  - Provenance templates
  - “Intelligent” generation of pictures

Possible Use Cases

- Journalism
- Generation of handbooks
- Communicating security incidents
  - Smart Home

Thank You!

Andreas Schreiber

www.DLR.de/sc/ivs

andreas.schreiber@dlr.de

@onyame